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EXAMINER
CANTELMO, GREGG

ART UNIT	PAPER NUMBER
1753	4

DATE MAILED: 12/31/2001

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 09/785,858	Applicant(s) LEIPHART
	Examiner Gregg Cantelmo	Art Unit 1753

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *Preliminary Amendment filed 2/16/01* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *35-74* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *35-74* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *16 February 2001* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☒ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 2 .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Response to Preliminary Amendment

1. In response to the preliminary amendment received February 16, 2001: Claims 1-34 have been cancelled. Claims 35-74 have been entered. An action on the merits of these claims follows.

Priority

2. This application discloses and claims only subject matter disclosed in prior Application No. 09/378,651, filed August 19, 1999, and names an inventor or inventors named in the prior application. Accordingly, this application appears to constitute a continuation.

Information Disclosure Statement

3. The information disclosure statement filed February 16, 2001 has been placed in the application file and the information referred to therein has been considered as to the merits.

Drawings

4. The drawings received February 16, 2001 are acceptable for examination purposes.

Specification

5. The disclosure is objected to because of the following informalities: the status of the parent application should be updated to the corresponding patent number and issue date. Appropriate correction is required.

6. The abstract of the disclosure is objected to because it exceeds 150 words. Correction is required. See MPEP § 608.01(b). Abstract should be brief, no longer than 150 words, and must be on a separate piece of paper. A150 word limit has been imposed to conform to PCT standards and for Pre-grant Publication purposes. Abstracts with more than 150 words that are objected to by OIPE shall be held there until corrected (see 37 CFR 1.72).

Claim Objections

7. Claim 42 is objected to under 37 CFR 1.75(c), as being of improper dependent form for failing to further limit the subject matter of a previous claim. Applicant is required to cancel the claim(s), or amend the claim(s) to place the claim(s) in proper dependent form, or rewrite the claim(s) in independent form. Claim 42 recites forming the third layer in the second PVD chamber. This is already recited in lines 17-18 of claim 35 and therefore does not appear to further limit claim 35.

Claim Rejections - 35 USC § 112

8. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

9. Claims 35-48 and 58-74 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

a. A broad range or limitation together with a narrow range or limitation that falls within the broad range or limitation (in the same claim) is considered indefinite, since the resulting claim does not clearly set forth the metes and bounds of the patent protection desired. Note the explanation given by the Board of Patent Appeals and Interferences in *Ex parte Wu*, 10 USPQ2d 2031, 2033 (Bd. Pat. App. & Inter. 1989), as to where broad language is followed by "such as" and then narrow language. The Board stated that this can render a claim indefinite by raising a question or doubt as to whether the feature introduced by such language is (a) merely exemplary of the remainder of the claim, and therefore not required, or (b) a required feature of the claims. Note also, for example, the decisions of *Ex parte Steigewald*, 131 USPQ 74 (Bd. App. 1961); *Ex parte Hall*, 83 USPQ 38 (Bd. App. 1948); and *Ex parte Hasche*, 86 USPQ 481 (Bd. App. 1949). In the present instance, claim 35 recites the broad recitation of the temperature not going below about 360° C (claim 35, lines 7-9), and the claim also recites that the outermost portion is at least about 360° C (claim 35, lines 11 and 12) which is the narrower statement of the range/limitation. This applies to claim 35 and each if the claims dependent upon claim 35.

b. Claims 35-48 and 58-74 are not particularly clear. Claim 35 recites depositing at least one of elemental titanium or a titanium alloy (lines 9-10) but

later in the same claim recites just titanium (lines 13 and 16). The alloy in line 13 being that between aluminum and titanium, not clearly drawn to a titanium alloy and aluminum. It is unclear whether applicant intentionally limits the genus of the titanium in lines 9-10 to that only of titanium as appears to be recited in lines 13 and 16. Clarity is respectfully requested. This issues is also present the independent claim 58;

c. Claim 38 is somewhat redundant. An aluminum alloy is an inherent mixture of aluminum. Recitation of a mixture thereof is no different from an aluminum alloy which is a mixture of aluminum. This also applies to claim 69;

d. Claim 41 is out of the scope of claim 35. Claim 35 claims maintaining the temperature of at least the outer portion of the first layer at a temperature of about 360° C during deposition. Yet claim 35 recites that the minimum temperature is *at least* 400° C. Therefore the limit set forth in claim 41 is below the lower limit of the independent claim, rendering the scope of the claims indefinite.

Claim Rejections - 35 USC § 103

10. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

11. Claims 35-45 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. patent No. 5,582,881 (Besser) in view of U.S. Patent Nos. 6,140,228 (Shan) and 5,925,933 (Colgan) and 5,909,639 (Marieb).

Besser discloses a method of sputtering (a PVD process) aluminum or aluminum alloy films on a semiconductor, then sputtering a titanium film on the aluminum layer, and thereafter sputtering a titanium nitride film on the alloy layer (abstract; col. 3, ll. 5-24; col. 4, ll. 13-51 as applied to claims 35, 49 and 58). During the deposition of the titanium layer the film is heated to approximately 350° C and by teaching of an upper limit of 450 ° C, can also be set above 360 ° C (paragraph bridging columns 3 and 4). After completion of the films on the substrate, the substrate is removed from the tool to allow for the processing of additional substrates. The titanium layer is deposited to 100 angstroms (col. 4, ll. 22 as applied to claims 36 and 37). The first layer can be either aluminum or an aluminum alloy (col. 3, ll. 12-15 as applied to claims 38 and 39). The layer deposited atop the aluminum is physical vapor deposited titanium (col. 4, ll. 12-15 as applied to claim 40). The titanium and titanium nitride layers are formed in the same chamber 230 (col. 4, ll. 12-15 and 29-33 as applied to claim 42). The titanium is deposited on the first layer of aluminum or aluminum alloy in a second processing chamber 230 and at the upper temperature for processing the titanium will form an alloy of the titanium and aluminum (as applied to claim 43).

The differences between the instant claims and Besser are that Besser does not disclose forming the outermost portion of the aluminum layer at a temperature of 400° C

or more (claim 35); or of preventing the outermost portion from cooling below 360° C during deposition of the first titanium layer (claim 35); or of forming the layers into a conductive line (claim 35); of forming the outermost portion of the aluminum layer at a temperature of 360° C or more (claim 41); of the first deposition temperature being at least 450° C (claim 44); of the first deposition temperature being greater than 450° C (claim 45).

With respect to forming the outermost portion of the aluminum layer at temperatures of at least 360 ° C and at least 400° C (claims 35 and 41):

Shan teaches that the remainder of the metal is deposited while the semiconductor wafer is held at a relatively high temperature (e.g., when the metal is an aluminum alloy, about 400° C. to about 500° C which allows the deposited metal to reflow through grain. The hot aluminum deposition can be continued until a fully planarized surface is obtained.

The motivation for depositing the outermost portion of the aluminum at temperatures of at least 400° C is to provide reflow of the aluminum film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by depositing the outer portion of the aluminum at a temperature of at least 400° C since it would have allowed the deposited metal to reflow through the grain and provided optimal conditions for forming a planarized aluminum film.

With respect to preventing the temperature of the outermost portion of the aluminum film from going below 360° C (claims 35, 44, and 45):

As discussed above, Besser teaches that the titanium is heater within a range from 250° C to 450 ° C, with an approximate exemplified temperature of 350° C. Besser also recognized that the Ti reacts with Al to form TiAl3 (col. 4, ll. 24-29). It is also known that maintaining temperatures of greater than 350° C will ensure reaction between titanium and aluminum to readily form TiAl3. Marieb discloses sputtering titanium over the aluminum layer and that heating the device from a range of about 350° C-450° C accelerates the reaction between the titanium and aluminum to form the desired TiAl3 product. The thickness of the film can be optimized so that all of all of the titanium film is reacted (col. 4, ll. 3-20).

Thus it would have been obvious to maintain the temperature to be greater than 350° C, held to be about 360° C, since it would have provided requisite temperature conditions to react the depositing titanium with the aluminum. TiAl3 increases the electromigration lifetime of the film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by ensuring that the temperature of the first layer does not go below about 360° C during deposition of the titanium since it would have provided optimal temperature conditions wherein the depositing titanium would have reacted with the aluminum to form a layer of TiAl3. Such a layer being known to have increased the electromigration lifetime of the multilayer device.

With respect to forming a conductive line (claim 35):

Colgan discloses forming an interconnect for a semiconductor device where an aluminum alloy film is sputtered on a substrate, with subsequent Ti and TiN sputtered in succession. The layers are then photolithographically etched to form pattern lines (Col. 2, line 62 through col. 3, line 7; col. 4, ll. 34-40).

The motivation for patterning the deposited layers is to form wiring patterns useful in interconnect structures.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by patterning the deposited layers as taught by Colgan since it would have formed wiring patterns for forming interconnects.

12. Claims 46-48 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb as applied to claims 35-45 above.

The difference not yet discussed is cooling the outermost portion of the first layer from the first deposition temperature by about 25° C or less (claims 46-48).

The claim limitations include a cooling by zero degrees (or less).

Besser forms the claimed structure and recognized the applicability of temperature ranges for the deposition of titanium from 250-450° C. Furthermore to change the titanium sputtered material to TiAl3 it is advantageous to set the deposition temperature to be from 350-450° C to increase the electromigration lifetime of the device (Marieb). Shan also teaches that temperatures of 400-500° C are desirable

when forming the outer portion of an aluminum film to provide adequate reflow of the aluminum to reduce void formation and form planar films.

Thus it would be apparent to form the aluminum film outer portion in a range of 400-500° C as taught by Shan and thereafter form the titanium film in a range of 350-500° C. Noting an overlap of these ranges, one of ordinary skill would have further found it obvious to use temperatures that overlap to provide optimal conditions with which both films can be formed without the need for changing process variables. Thus a temperature near or about that which both of these films can be deposited to achieve the desired result would have been preferred to reduce the process time required for setting different temperature conditions.

In addition the limitations set forth in claims 46-48 are drawn to particular ranges of temperatures and does not appear to provide any novel effect not achieved by the process conditions set forth in the prior art of record.

Generally, differences in ranges will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such ranges is critical. In re Aller, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955). In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser such that any temperature relationship between the first and second films was applied so long as the temperatures achieved the same resultant multilayer device as formed by the prior art of record above. Furthermore, it has been held that when the difference between a

claimed invention and the prior art is the range or value of a particular variable, then a prima facie rejection is properly established when the difference in the range or value is minor. Titanium Metals Corp. of Am. v. Banner, 778 F.2d 775, 783, 227 USPQ 773, 779 (Fed. Cir. 1985).

13. Claims 49-51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb.

Besser discloses a method of sputtering (a PVD process) aluminum or aluminum alloy films on a semiconductor, then sputtering a titanium film on the aluminum layer, and thereafter sputtering a titanium nitride film on the alloy layer (abstract; col. 3, ll. 5-24; col. 4, ll. 13-51 as applied to claim 49). During the deposition of the titanium layer the film is heated to approximately 350° C and by teaching of an upper limit of 450 ° C, can also be set above 360 ° C (paragraph bridging columns 3 and 4). After completion of the films on the substrate, the substrate is removed from the tool to allow for the processing of additional substrates. The titanium layer is deposited to 100 angstroms (col. 4, ll. 22 as applied to claims 55 and 56). The first layer can be either aluminum (col. 3, ll. 12-15 as applied to claim 57).

The differences between the instant claims and Besser are that Besser does not disclose forming the outermost portion of the aluminum layer at a temperature of 400° C or more (claim 49); or of preventing the outermost portion from cooling below 360° C during deposition of the first titanium layer (claim 49); or of forming the layers into a conductive line (claim 49); of the first deposition temperature being at least 450° C (claim 50); of the first deposition temperature being greater than 450° C (claim 51).

With respect to forming the outermost portion of the aluminum layer at temperatures of at least 400° C (claim 49):

Shan teaches that the remainder of the metal is deposited while the semiconductor wafer is held at a relatively high temperature (e.g., when the metal is an aluminum alloy, about 400° C. to about 500° C which allows the deposited metal to reflow through grain. The hot aluminum deposition can be continued until a fully planarized surface is obtained.

The motivation for depositing the outermost portion of the aluminum at temperatures of at least 400° C is to provide reflow of the aluminum film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by depositing the outer portion of the aluminum at a temperature of at least 400° C since it would have allowed the deposited metal to reflow through the grain and provided optimal conditions for forming a planarized aluminum film.

With respect to preventing the temperature of the outermost portion of the aluminum film from going below 360° C (claims 49-51):

As discussed above, Besser teaches that the titanium is heater within a range from 250° C to 450 ° C, with an approximate exemplified temperature of 350° C. Besser also recognized that the Ti reacts with Al to form TiAl3 (col. 4, ll. 24-29). It is also known that maintaining temperatures of greater than 350° C will ensure reaction

between titanium and aluminum to readily form TiAl3. Marieb discloses sputtering titanium over the aluminum layer and that heating the device from a range of about 350° C-450° C accelerates the reaction between the titanium and aluminum to form the desired TiAl3 product. The thickness of the film can be optimized so that all of all of the titanium film is reacted (col. 4, ll. 3-20).

Thus it would have been obvious to maintain the temperature to be greater than 350° C, held to be about 360° C, since it would have provided requisite temperature conditions to react the depositing titanium with the aluminum. TiAl3 increases the electromigration lifetime of the film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by ensuring that the temperature of the first layer does not go below about 360° C during deposition of the titanium since it would have provided optimal temperature conditions wherein the depositing titanium would have reacted with the aluminum to form a layer of TiAl3. Such a layer being known to have increased the electromigration lifetime of the multilayer device.

With respect to forming a conductive line (claim 49):

Colgan discloses forming an interconnect for a semiconductor device where an aluminum alloy film is sputtered on a substrate, with subsequent Ti and TiN sputtered in succession. The layers are then photolithographically etched to form pattern lines (Col. 2, line 62 through col. 3, line 7; col. 4, ll. 34-40).

The motivation for patterning the deposited layers is to form wiring patterns useful in interconnect structures.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by patterning the deposited layers as taught by Colgan since it would have formed wiring patterns for forming interconnects.

14. Claims 52-54 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb as applied to claims 49-51 and 55-57 above.

The difference not yet discussed is cooling the outermost portion of the first layer from the first deposition temperature by about 25° C or less (claims 46-48).

The claim limitations include a cooling by zero degrees (or less).

Besser forms the claimed structure and recognized the applicability of temperature ranges for the deposition of titanium from 250-450° C. Furthermore to change the titanium sputtered material to TiAl3 it is advantageous to set the deposition temperature to be from 350-450° C to increase the electromigration lifetime of the device (Marieb). Shan also teaches that temperatures of 400-500° C are desirable when forming the outer portion of an aluminum film to provide adequate reflow of the aluminum to reduce void formation and form planar films.

Thus it would be apparent to form the aluminum film outer portion in a range of 400-500° C as taught by Shan and thereafter form the titanium film in a range of 350-500° C. Noting an overlap of these ranges, one of ordinary skill would have further

found it obvious to use temperatures that overlap to provide optimal conditions with which both films can be formed without the need for changing process variables. Thus a temperature near or about that which both of these films can be deposited to achieve the desired result would have been preferred to reduce the process time required for setting different temperature conditions.

In addition the limitations set forth in claims 46-48 are drawn to particular ranges of temperatures and does not appear to provide any novel effect not achieved by the process conditions set forth in the prior art of record.

Generally, differences in ranges will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such ranges is critical. In re Aller, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955). In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser such that any temperature relationship between the first and second films was applied so long as the temperatures achieved the same resultant multilayer device as formed by the prior art of record above. Furthermore, it has been held that when the difference between a claimed invention and the prior art is the range or value of a particular variable, then a prima facie rejection is properly established when the difference in the range or value is minor. Titanium Metals Corp. of Am. v. Banner, 778 F.2d 775, 783, 227 USPQ 773, 779 (Fed. Cir. 1985).

15. Claims 58-60 and 62-71 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb.

Besser discloses a method of sputtering (a PVD process) aluminum or aluminum alloy films on a semiconductor, then sputtering a titanium film on the aluminum layer, and thereafter sputtering a titanium nitride film on the alloy layer (abstract; col. 3, ll. 5-24; col. 4, ll. 13-51 as applied to claim 58). During the deposition of the titanium layer the film is heated to approximately 350° C and by teaching of an upper limit of 450 ° C, can also be set above 360 ° C (paragraph bridging columns 3 and 4). After completion of the films on the substrate, the substrate is removed from the tool to allow for the processing of additional substrates. The titanium nitride is formed atop the titanium layer within chamber 230 (as applied to claim 59). The titanium and third layer are formed in the same chamber 230 (as applied to claim 62). The first aluminum layer is formed in a first chamber and the titanium and third layer are formed in the same chamber 230 without moving the substrate threrefrom (as applied to claims 63-64). The titanium layer is deposited to 100 angstroms (col. 4, ll. 22 as applied to claims 67 and 68). The first layer can be either aluminum or an aluminum alloy (col. 3, ll. 12-15 as applied to claims 69 and 70). The layer deposited atop the aluminum is physical vapor deposited titanium (col. 4, ll. 12-15 as applied to claim 71).

The differences between the instant claims and Besser are that Besser does not disclose forming the outermost portion of the aluminum layer at a temperature of 400° C or more (claim 58); or of preventing the outermost portion from cooling below 360° C during deposition of the first titanium layer (claim 58); or of forming the layers into a

conductive line (claim 58) of alloying all of the titanium with the aluminum (claim 60); of the first deposition temperature being at least 450° C (claim 65); of the first deposition temperature being greater than 450° C (claim 66).

With respect to forming the outermost portion of the aluminum layer at temperatures of at least 400° C (claim 58):

Shan teaches that the remainder of the metal is deposited while the semiconductor wafer is held at a relatively high temperature (e.g., when the metal is an aluminum alloy, about 400° C. to about 500° C which allows the deposited metal to reflow through grain. The hot aluminum deposition can be continued until a fully planarized surface is obtained.

The motivation for depositing the outermost portion of the aluminum at temperatures of at least 400° C is to provide reflow of the aluminum film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by depositing the outer portion of the aluminum at a temperature of at least 400° C since it would have allowed the deposited metal to reflow through the grain and provided optimal conditions for forming a planarized aluminum film.

With respect to preventing the temperature of the outermost portion of the aluminum film from going below 360° C (claims 58 and 60):

As discussed above, Besser teaches that the titanium is heater within a range from 250° C to 450 ° C, with an approximate exemplified temperature of 350° C. Besser also recognized that the Ti reacts with Al to form TiAl3 (col. 4, ll. 24-29). It is also known that maintaining temperatures of greater than 350° C will ensure reaction between titanium and aluminum to readily form TiAl3. Marieb discloses sputtering titanium over the aluminum layer and that heating the device from a range of about 350° C-450° C accelerates the reaction between the titanium and aluminum to form the desired TiAl3 product. The thickness of the film can be optimized so that all of all of the titanium film is reacted (col. 4, ll. 3-20).

Thus it would have been obvious to maintain the temperature to be greater than 350° C, held to be about 360° C, since it would have provided requisite temperature conditions to react the depositing titanium with the aluminum. TiAl3 increases the electromigration lifetime of the film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by ensuring that the temperature of the first layer does not go below about 360° C during deposition of the titanium since it would have provided optimal temperature conditions wherein the depositing titanium would have reacted with the aluminum to form a layer of TiAl3. Such a layer being known to have increased the electromigration lifetime of the multilayer device.

With respect to forming a conductive line (claim 58):

Colgan discloses forming an interconnect for a semiconductor device where an aluminum alloy film is sputtered on a substrate, with subsequent Ti and TiN sputtered in succession. The layers are then photolithographically etched to form pattern lines (Col. 2, line 62 through col. 3, line 7; col. 4, ll. 34-40).

The motivation for patterning the deposited layers is to form wiring patterns useful in interconnect structures.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by patterning the deposited layers as taught by Colgan since it would have formed wiring patterns for forming interconnects.

16. Claims 72-74 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb as applied to claims 58-60 and 62-71 above.

The difference not yet discussed is cooling the outermost portion of the first layer from the first deposition temperature by about 25° C or less (claims 72-74).

The claim limitations include a cooling by zero degrees (or less).

Besser forms the claimed structure and recognized the applicability of temperature ranges for the deposition of titanium from 250-450° C. Furthermore to change the titanium sputtered material to TiAl3 it is advantageous to set the deposition temperature to be from 350-450° C to increase the electromigration lifetime of the device (Marieb). Shan also teaches that temperatures of 400-500° C are desirable

when forming the outer portion of an aluminum film to provide adequate reflow of the aluminum to reduce void formation and form planar films.

Thus it would be apparent to form the aluminum film outer portion in a range of 400-500° C as taught by Shan and thereafter form the titanium film in a range of 350-500° C. Noting an overlap of these ranges, one of ordinary skill would have further found it obvious to use temperatures that overlap to provide optimal conditions with which both films can be formed without the need for changing process variables. Thus a temperature near or about that which both of these films can be deposited to achieve the desired result would have been preferred to reduce the process time required for setting different temperature conditions.

In addition the limitations set forth in claims 46-48 are drawn to particular ranges of temperatures and does not appear to provide any novel effect not achieved by the process conditions set forth in the prior art of record.

Generally, differences in ranges will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such ranges is critical. In re Aller, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955). In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser such that any temperature relationship between the first and second films was applied so long as the temperatures achieved the same resultant multilayer device as formed by the prior art of record above. Furthermore, it has been held that when the difference between a

claimed invention and the prior art is the range or value of a particular variable, then a prima facie rejection is properly established when the difference in the range or value is minor. Titanium Metals Corp. of Am. v. Banner, 778 F.2d 775, 783, 227 USPQ 773, 779 (Fed. Cir. 1985).

17. Claim 61 is rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb as applied to claims 58-60 and 62-71 above.

The difference not yet discussed is depositing each film in a separate chamber.

Besser has a forth chamber for depositing additional films. Besser prefers to deposit the titanium and titanium nitride in the same chamber however Besser recognized that it is known in the art to deposit the titanium and titanium nitride films in separate chambers (col. 2, ll. 5-25). The benefit for separating the titanium and titanium nitride into different chambers is to prevent cross-contamination of the respective films for successive substrates. The only apparent benefit disclosed by Besser for using a single chamber to form both the Ti and TiN films is to improve the throughput of the system.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by forming each film in separate chambers since it would have enhanced the purity of each film deposited in the multilayer arrangement.

Double Patenting

18. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the

unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. See *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970);and, *In re Thorington,* 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 CFR 1.130(b).

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

19. Claims 35-45, 49-51, 55-60 and 62-71 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-9 of U.S. Patent No. 6,224,942 (USPAT '942) in view of U.S. patent No. 6,140,228 (Shan).

USPAT '942 claims a method of forming an aluminum comprising line having a titanium nitride comprising layer there on, the method comprising:

in a processing tool, physical vapor depositing a first layer comprising at least one of elemental aluminum or an aluminum alloy over a substrate in a first chamber;

physical vapor depositing at least one of elemental titanium or a titanium alloy on the first layer in a second chamber of the too while at least an outer portion of the first layer is at a temperature of at least about 360° C, and forming therefrom a second layer comprising an alloy of titanium and the aluminum from the first layer in the second chamber during said depositing, the alloy having a higher melting point that than of the first layer, and wherein essentially all the physical vapor deposited titanium alloys with the aluminum of the first layer; physical vapor depositing a third layer comprising titanium nitride on the second layer in a second chamber of the processing tool;

removing the substrate from the processing tool after depositing the third layer; and forming first, second and third layers into a conductive line (prior art claims 1 and 8 as applied to instant claims 35 and 42). The second layer is deposited at the same thickness (prior art claims 2 and 3 as applied to instant claims 36 and 37, respectively). The first layer consists of elemental aluminum (claims 4 and 5 as applied to instant claims 38 and 39 respectively). The depositing at least one of elemental titanium or a titanium alloy comprises depositing elemental titanium (prior at claim 6 as applied to claim 40). The outer portion of the first layer is at least about 360° C during deposition (prior art claim 7 as applied to instant claim 41). The third layer is formed in the second chamber (prior art claim 8 as applied to claim 42). The method further wherein depositing of elemental titanium or a titanium alloy on the first layer in the second chamber of the processing tool comprises depositing a titanium alloy layer, and forming thereform a second layer comprising an alloy of titanium and the aluminum from the first layer in the second chamber during said depositing (prior art claim 9 as applied to claim 43).

The differences between the instant claims and USPAT '942 are that USPAT '942 does not appear to claim depositing the aluminum or aluminum alloy at a temperature of at least 400 ° C (claim 35), at least about 450° C (claim 44) or greater than 450° C (claim 45).

The outer portion of the first layer is at least about 360° C during deposition (prior art claim 7).

Shan teaches that the remainder of the metal is deposited while the semiconductor wafer is held at a relatively high temperature (e.g., when the metal is an aluminum alloy, about 400° C. to about 500° C which allows the deposited metal to reflow through grain. The hot aluminum deposition can be continued until a fully planarized surface is obtained.

The motivation for depositing the outermost portion of the aluminum at temperatures of at least 400° C is to provide reflow of the aluminum film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of USPAT '942 by depositing the outer portion of the aluminum at a temperature of at least 400° C since it would have allowed the deposited metal to reflow through the grain and provided optimal conditions for forming a planarized aluminum film.

With respect to claims 49-57:

USPAT '942 claims a method of forming an aluminum comprising line having a titanium nitride comprising layer there on, the method comprising: forming a first layer comprising at least one of elemental aluminum or an aluminum alloy over a substrate; after forming the first layer depositing titanium onto the first layer while at least an outer portion of the first layer is at a temperature of at least about 360° C, and forming therefrom a second layer comprising an alloy of titanium and the aluminum from the first layer, forming a third layer comprising titanium nitride on the second layer; and forming first, second and third layers into a conductive line (prior art claim 1 as applied to

instant claim 49). The second layer is deposited at the same thickness (prior art claims 2 and 3 as applied to instant claims 55 and 56, respectively). The first layer consists of elemental aluminum (claim 5 as applied to instant claims 57).

The differences between the instant claims and USPAT '942 are that USPAT '942 does not appear to claim depositing the aluminum or aluminum alloy at a temperature of at least 400 ° C (claim 49), at least about 450° C (claim 50) or greater than 450° C (claim 51).

The outer portion of the first layer is at least about 360° C during deposition (prior art claim 7).

Shan teaches that the remainder of the metal is deposited while the semiconductor wafer is held at a relatively high temperature (e.g., when the metal is an aluminum alloy, about 400° C. to about 500° C which allows the deposited metal to reflow through grain. The hot aluminum deposition can be continued until a fully planarized surface is obtained.

The motivation for depositing the outermost portion of the aluminum at temperatures of at least 400° C is to provide reflow of the aluminum film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of USPAT '942 by depositing the outer portion of the aluminum at a temperature of at least 400° C since it would have allowed the deposited metal to reflow through the grain and provided optimal conditions for forming a planarized aluminum film.

With respect to claims 58-74

USPAT '942 claims a method of forming an aluminum comprising line having a titanium nitride comprising layer there on, the method comprising:

physical vapor depositing a first layer comprising at least one of elemental aluminum or an aluminum alloy over a substrate at least an outermost portion of the first layer being deposited at a first deposition temperature of at least 360° C; after the first layer physical vapor depositing at least one of elemental titanium or a titanium alloy on the first layer while at least an outer portion of the first layer is at a temperature of at least about 360° C, and forming therefrom a second layer comprising an alloy of titanium and the aluminum from the first layer during said depositing, the alloy having a higher melting point that than of the first layer; physical vapor depositing a third layer comprising titanium nitride on the second layer; and forming first, second and third layers into a conductive line (prior art claims 1 and 8 as applied to instant claims 58 and 42). The claims mention no other layers formed thus the titanium nitride is formed atop and in contact with the second layer (as applied to claim 59). Essentially all of the PVD deposited titanium alloys with the aluminum of the first layer (claim 1 as applied to claim 60). The aluminum is deposited in a first chamber and the titanium and titanium nitride films are deposited in a second chamber (prior art claims 1 and 8 as applied to claim 62-64).

The second layer is deposited at the same thickness (prior art claims 2 and 3 as applied to instant claims 67 and 68, respectively). The first layer consists of elemental aluminum (claims 4 and 5 as applied to instant claims 69 and 70, respectively). The

depositing at least one of elemental titanium or a titanium alloy comprises depositing elemental titanium (prior at claim 6 as applied to claim 71).

The differences between the instant claims and USPAT '942 are that USPAT '942 does not appear to claim depositing the aluminum or aluminum alloy at a temperature of at least 400 ° C (claim 58), at least about 450° C (claim 65) or greater than 450° C (claim 66).

The outer portion of the first layer is at least about 360° C during deposition (prior art claim 7).

Shan teaches that the remainder of the metal is deposited while the semiconductor wafer is held at a relatively high temperature (e.g., when the metal is an aluminum alloy, about 400° C. to about 500° C which allows the deposited metal to reflow through grain. The hot aluminum deposition can be continued until a fully planarized surface is obtained.

The motivation for depositing the outermost portion of the aluminum at temperatures of at least 400° C is to provide reflow of the aluminum film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of USPAT '942 by depositing the outer portion of the aluminum at a temperature of at least 400° C since it would have allowed the deposited metal to reflow through the grain and provided optimal conditions for forming a planarized aluminum film.

20. Claims 61 is rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-9 of USPAT '942 in view of Shan as applied to claims 35-45, 49-51, 55-60 and 62-71 above and in further view of Besser

The difference not yet discussed is of depositing each layer in separate chambers (claim 61).

Besser teaches that it is known in the art to form Al, Ti, and TiN in separate chambers (col. 2, ll. 10-21). The advantage is that it isolates each film and prevents cross contamination of successive films within a single chamber. The drawback is lowers the throughput of the system and process. The worker in the art would have selected separate chambers for each film to ensure film purity and prevent cross contamination even at a lower throughput. Furthermore using a single chamber to deposit multiple and different materials requires more frequent cleaning of the chamber.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of USPAT '942 by forming each film in separate chambers since it would have enhanced the purity of each film deposited in the multilayer arrangement.

21. Claims 46-48, 52-54 and 72-74 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-9 of USPAT '942 in view of Shan as applied to claims 35-45, 49-51, 55-60 and 62-71.

The difference not yet discussed is cooling the outermost portion of the first layer from the first deposition temperature by about 25° C or less (claims 46-48, 52-54 and 72-74).

The claim limitations include a cooling by zero degrees (or less).

The limitations set forth in claims are drawn to particular ranges of temperatures and does not appear to provide any novel effect not achieved by the process conditions set forth in the prior art of record.

Generally, differences in ranges will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such ranges is critical. In re Aller, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955). In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of USPAT '942 such that any temperature relationship between the first and second films was applied so long as the temperatures achieved the same resultant multilayer device as formed by the prior art of record above. Furthermore, it has been held that when the difference between a claimed invention and the prior art is the range or value of a particular variable, then a prima facie rejection is properly established when the difference in the range or value is minor. Titanium Metals Corp. of Am. v. Banner, 778 F.2d 775, 783, 227 USPQ 773, 779 (Fed. Cir. 1985).

Conclusion

22. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Gregg Cantelmo whose telephone number is (703) 305-

0635. The examiner can normally be reached on Monday through Thursday from 8:00 a.m. to 5:30 p.m.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen, can be reached on (703) 308-3322.

FAX communications should be sent to the appropriate FAX number: (703) 872-9311 for After Final Responses only; (703) 872-9310 for all other responses. FAXES received after 4 p.m. will not be processed until the following business day.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0661.

gc

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